NASA-CR-194127

CALIFORNIA INSTITUTE OF TECHNOLOGY
DIVISION OF PHYSICS, MATHEMATICS, AND ASTRONOMY
SPACE RADIATION LABORATORY
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STATUS REPORT

for the period of

1 October 1992 - 30 September 1993

submitted to

THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

for the Cosmic Physics portion of

RESEARCH IN COSMIC AND GAMMA RAY ASTROPHYSICS
NAGW-1919

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August 27, 1993

(NASA-CR-194127) RESEARCH IN COSMIC AND GAMMA RAY ASTROPHYSICS: COSMIC PHYSICS PORTION Status Report, 1 Oct. 1992 - 30 Sep. 1993 (California Inst. of Tech.) 20 p

N94-13211

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1. INTRODUCTION

Research in particle astrophysics at the Space Radiation Laboratory (SRL) of the California Institute of Technology is supported under NASA Grant NAGW-1919. A three-year proposal for continuation of support was submitted a year ago and put into effect 1 October 1992. This report is the combined progress report and continuation application called for under the Federal Demonstration Project. Gamma-ray Astrophysics at SRL is separately supported under NAGW-1919 and will be separately summarized and proposed.

This report will document progress and plans for our particle spectroscopy activities and for related data analysis, calibration, and community service activities. A bibliography and a budget will be attached as appendices.

The Caltech SRL research program includes a heavy emphasis on elemental and isotopic spectroscopy of energetic particles in the cosmic radiation; in solar, interplanetary, and anomalous "cosmic" radiation; and in planetary magnetospheres as discussed below.

2. STATUS REVIEW

2.1. Data Analysis from the Isotope Matter/Antimatter experiment (IMAX)

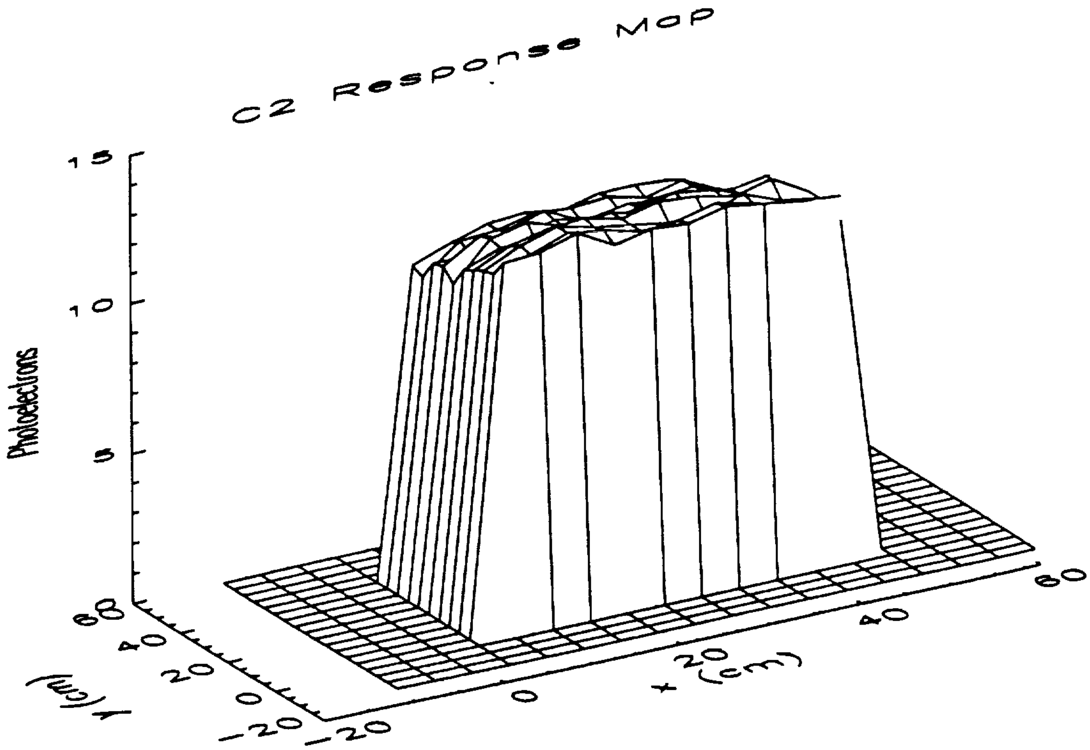
The Isotope Matter/Antimatter experiment (IMAX) is a collaborative effort with R. E. Streitmatter, J. F. Ormes, and colleagues at GSFC, S. Stochaj and W. R. Webber at NMSU, M. Simon of the University of Siegen, and I. L. Rasmussen of DSRI.

The IMAX payload was launched successfully from Lynn Lake, Canada in mid-July of 1992 and floated for ~18 hours at an average altitude of ~120,000 ft., recording more than 3×10^6 events during float. Caltech graduate student Allan Labrador is working on IMAX data analysis for his PhD thesis. Research Fellow Andrew Davis recently joined the IMAX team, and is now assisting in the data analysis. Much of the effort over the first year since launch has been devoted to writing and debugging analysis software that can deal with the large quantify of flight data obtained, as well as with prelaunch calibration data using cosmic ray muons.

Aerogel Cherenkov Counter Analysis

Caltech is responsible for calibrating and developing the data analysis algorithms for the two Aerogel Cherenkov counters on IMAX. These counters are designed to measure the velocity of nuclei with energies >2 GeV/nuc to enable H and He isotope analysis, and they also serve as an anticoincidence to identify high energy negative particles (electrons, muons, pions, kaons) that might masquerade as antiprotons. Each of these is ~9 cm thick with an active area of ~50 cm x 50 cm.

Figure 2.1-1 shows maps of the response of C2 and C3 in units of photoelectrons from a single $Z = 1$, $\beta = 1$ particle. The mean number of photoelectrons (~12 from C2 and ~13 from C3) should be sufficient to achieve the IMAX science objectives. We have also mapped the index of refraction of both counters (Table 2.1-1). While there is no evidence for significant index of refraction variations, the average index of ~1.043 is smaller than the design index of 1.055. Although the origin of this difference is still under investigation, it is not expected to have a significant effect. It should, for example allow us to measure antiprotons and H and He isotopes to somewhat higher energy than was planned.



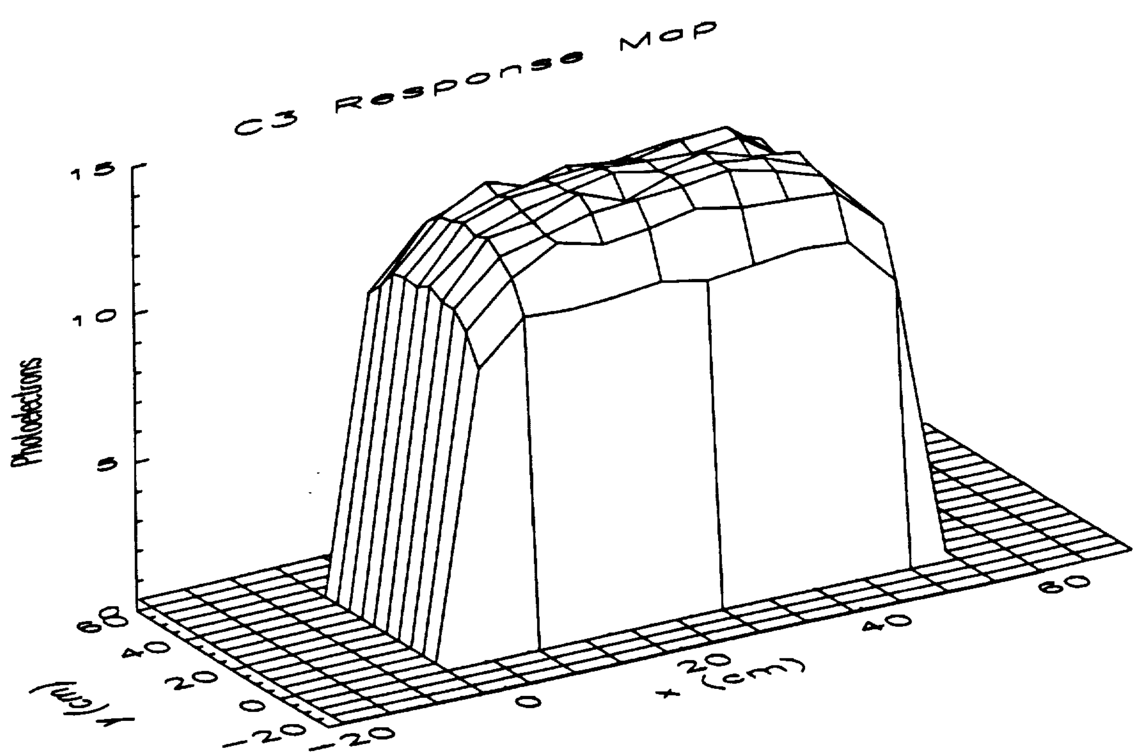


Figure 2.1-1 Cherenkov Response Map

C2 Index of Refraction Map

(Mean Index = 1.043, binsize = 8.4 cm x 8.4 cm)

1.041 ± 0.003	1.046 ± 0.002	1.042 ± 0.002	1.043 ± 0.002	1.047 ± 0.003
1.043 ± 0.003	1.043 ± 0.002	1.043 ± 0.002	1.043 ± 0.002	1.044 ± 0.002
1.043 ± 0.003	1.042 ± 0.002	1.043 ± 0.002	1.041 ± 0.002	1.046 ± 0.002
1.041 ± 0.003	1.041 ± 0.002	1.042 ± 0.002	1.041 ± 0.002	1.043 ± 0.002
1.049 ± 0.005	1.040 ± 0.002	1.039 ± 0.002	1.041 ± 0.002	1.044 ± 0.004

C3 Index of Refraction Map

(Mean Index = 1.044, binsize = 10.4 cm x 10.0 cm)

1.046 ± 0.003	1.043 ± 0.002	1.042 ± 0.002	1.044 ± 0.002	1.045 ± 0.003
1.046 ± 0.002	1.046 ± 0.002	1.043 ± 0.002	1.041 ± 0.002	1.046 ± 0.003
1.045 ± 0.002	1.043 ± 0.002	1.044 ± 0.002	1.043 ± 0.002	1.044 ± 0.002
1.044 ± 0.003	1.046 ± 0.002	1.042 ± 0.002	1.044 ± 0.002	1.046 ± 0.003
1.043 ± 0.003	1.046 ± 0.003	1.041 ± 0.003	1.045 ± 0.003	1.044 ± 0.003

Table 2.1-1 Index of Refraction Maps

Velocity and Mass Determination Algorithms

Preliminary algorithms have now been developed to measure velocity with the Cherenkov counters. When these velocity measurements are combined with rigidity measurements from the trajectory system it is possible to determine isotope mass. Figure 2.1-2, which shows a preliminary mass histogram for He with >2 GeV/nuc, indicates that He isotope analysis should be possible at these high energies.

Other IMAX Activities

The development of algorithms for the time of flight and trajectory systems is also well along and a variety of such software has been exchanged between the various IMAX groups. The collaboration is working well, in spite of the inevitable complications caused by differences in computer hardware and operating systems between the groups,

A number of IMAX talks and papers were presented at the Spring APS and the recent 23rd ICRC meeting in Calgary.

2.2. The ISOtope Magnet eXperiment (ISOMAX)

ISOMAX is a new balloon-borne super-conducting magnet experiment that will be designed to measure the isotopic composition of cosmic ray nuclei from Li to Si ($Z = 3$ to 14) in the energy range from ~0.2 to -3 Gev/nuc. It will combine a dual-coil superconducting magnet with high resolution drift chambers to obtain a magnetic spectrometer with an MDR of 0 GV. When combined with high resolution time-of-flight (TOF) and Cherenkov velocity-measuring devices, the resulting mass spectrometer will be capable of resolving cosmic ray isotopes such as ^{10}Be over the entire energy range from 0.2 to ~4 GeV/nuc with good mass resolution. Figure 2.2-1 shows a schematic view of the experiment, which is a collaborative effort between GSFC, Caltech, the University of Siegen, and DSRI.

Caltech is responsible for a significant fraction of the ISOMAX hardware, which is presently scheduled for launch in 1995, from Canada, aiming for a subsequent long-duration Antarctic flight. Caltech's major responsibilities include the Aerogel Cherenkov counter and its associated electronics, the pressure vessel, the on-board data-recording system and the altitude/position sensing system. We are developing new low-power VLSI circuitry to readout the Cherenkov signals with minimum weight and power impact during long duration balloon flights. We summarize here progress during the past year.

2.2.1. Cherenkov Counters Development

The ISOMAX Cherenkov counter will build on our experience with the C2 and C3 counters in IMAX. In particular, we are investigating ways to improve the light yield and velocity resolution. The index of refraction of the counter in ISOMAX will be tuned; for our first flight we are aiming for an index of $n = 1.1$. We are working with I. L. Rasmussen at DSRI to obtain large blocks of this index. Investigations now underway include:

Waveshifter Tests

We are investigating the use of wavelength-shifter dyes in aerogel Cherenkov detectors to increase light yield. We have sprayed P-terphenyl waveshifter on the surface of the white millipore paper on the lid and floor of one of our IMAX counters, resulting in a 10-15% increase in light yield.

Using a small test counter, we are testing the idea of suspending waveshifter dye on stretched membranes of Teflon FEP film, which has good transmission down to 250nm. These membranes

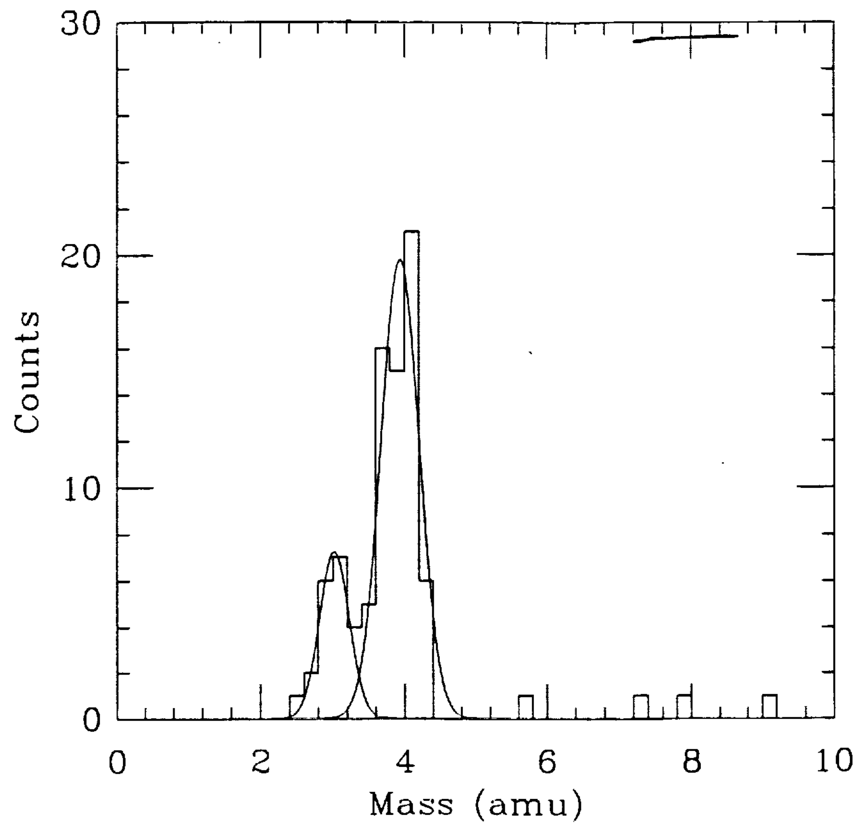


Figure 2.1-2 Preliminary He Mass Spectrum >2 Gev/nuc (first few hours of data)

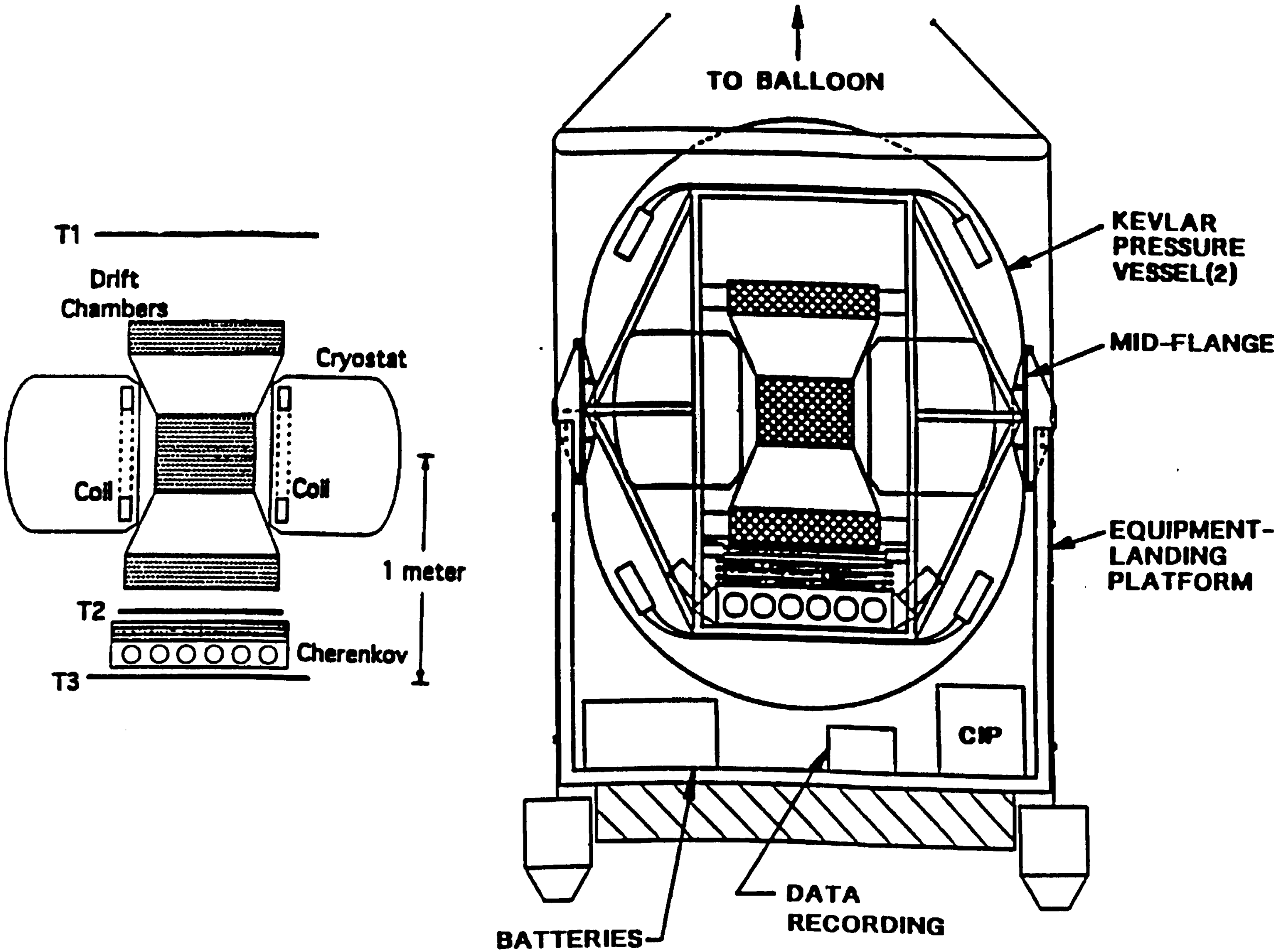


Figure 2.2-1 *A schematic diagram of the ISOMAX instrument and gondola.*

may be stacked between multiple aerogel radiators in a light-diffusion box, thus shifting a large fraction of UV Cherenkov light to longer wavelengths before it is absorbed. Preliminary results indicate that this technique will produce at least as much gain in light yields as spraying the millipore with waveshifter.

New Detector Materials

We are testing new materials for use as diffuse and specular reflectors in our counters. We find that millipore degrades significantly over several years, so we are testing thin layers of Spectralon as a more durable alternative. We are also testing aluminized mylar with a magnesium fluoride coating for use as a specular reflector inside the PMT shields. We have been using bare aluminized mylar for this purpose, and the oxidation of the aluminum over time may result in lower light yields.

Aerogel Stability

In lab muon runs during the Spring of 1992, the light yield from the individual aerogel blocks used in the IMAX flight ranged from 7.2 pe's to 7.7 pe's, depending on the radiator being tested. In the spring of 1993 we tested these radiators again using the same muon telescope setup. For each radiator, we found a decrease in light yield compared with the 1992 yields. The decrease ranged from 8% for some radiators to 16% for others. However, the millipore in the light integration box was almost two years old by Spring 1993. When this millipore was replaced, we found the decrease in light yield to be only 5% in the worst case. This is an upper limit on the degradation of the aerogels over this time period, since there could be other contributing factors. Thus we appear to have control over the aerogel degradation problem that we discovered during the early 1980's.

2.3. ISOMAX Pressure Vessel

We are currently looking at different hardware/fabrication concepts for the ISOMAX pressure vessel. While the use of a Kevlar structural material is the baseline approach, we are also considering other materials, such as a carbon fiber composite, with an idea towards simplifying fabrication and reducing costs. Figure 2.2-2 shows two hardware concepts being looked at in more detail, with respect to the Kevlar approach. We anticipate circulating this drawing to potential fabrication vendors as a starting point for technical discussions, and eventual quotes.

2.4. Data Recording System

The on-board data recording system will make use of state-of-the-art digital tape technology with the aim of achieving a redundant recording capability with an (expandable) capacity of 5 G bytes or more. We have recently surveyed three existing tape drive technologies (QIC, 4 mm, 8 mm) and are on the process of assessing their data rates capacity, cost effectiveness, and reliability. It appears that QIC has inadequate capacity (for a given cost) and our baseline approach presently employs two Exabyte 8-mm, C4-8500 cartridge tape recorders, each capable of 5 G byte capacity. Although the 8-mm approach does not match the throughput performance of the 4-mm drives, it has a combination of capacity, cost, reliability, and broad market acceptance that is yet to be matched. A number of distributors have been contacted and a decision will be made in the next few months.

2.5. Custom VLSI Electronics

Our laboratory is currently developing low-power custom VLSI pulse height analysis chains for the ACE mission. We are drawing on this experience to develop low-power VLSI ADC chains for use in long-duration balloon experiments, including the Cherenkov counter in ISOMAX. Although their have been some schedule delays, the ACE development is proceeding as planned (See Section 2.6.5). The adaptation of these circuits to ISOMAX will proceed once the ACE development is completed.

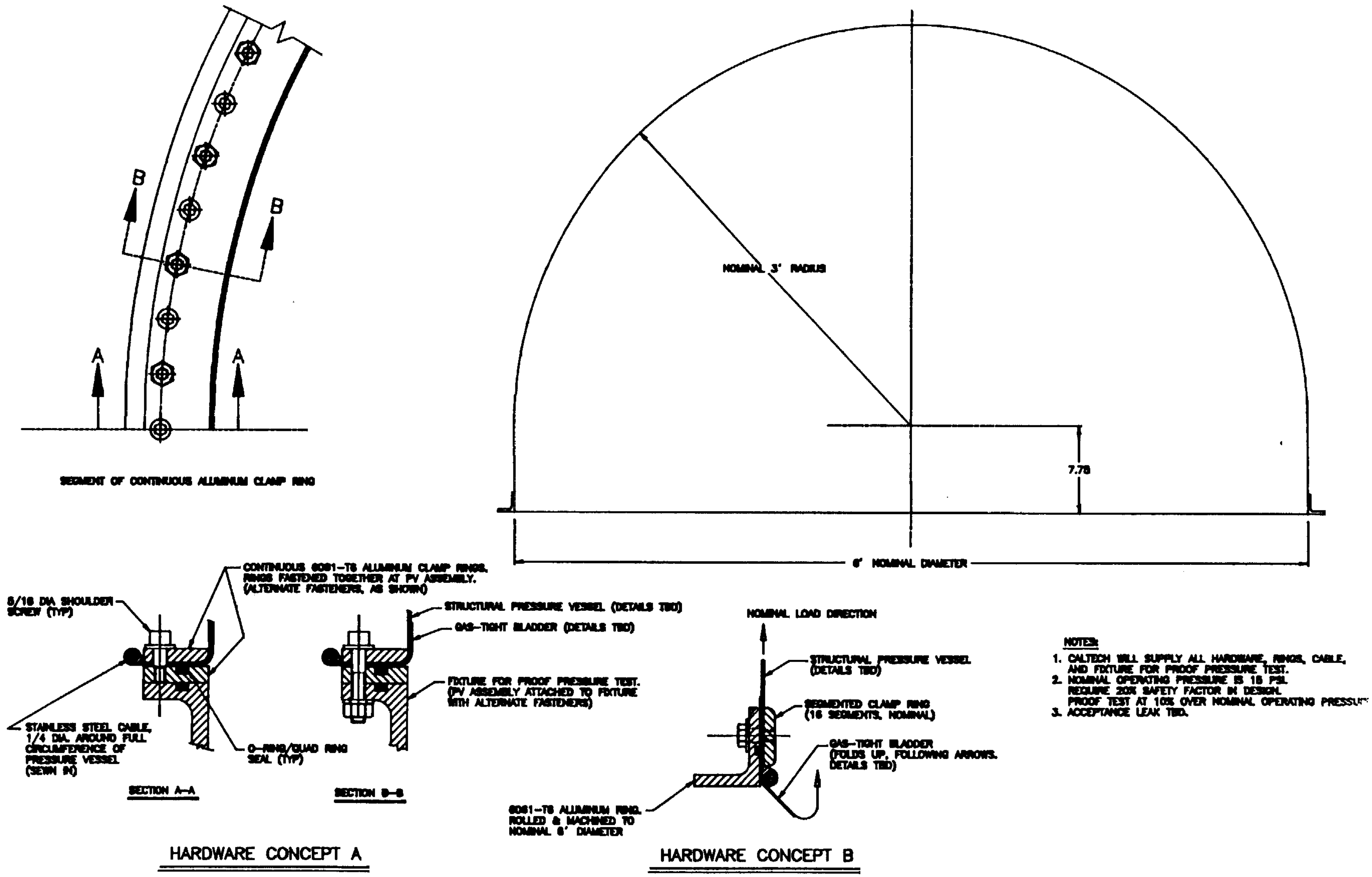


Figure 2.2-2 ISOMAX Pressure Vessel Concepts

2.6. Experiments on Existing NASA Spacecraft

2.6.1. An Electron/Isotope Spectrometer (EIS) Launched on IMP-7 in 1972 and on IMP-8 in 1973

These experiments are designed to measure the energy spectra of electrons and positrons (0.16 to ~6 MeV), and the differential energy spectra of the nuclear isotopes of hydrogen, helium, lithium, and beryllium (~2 to 50 MeV/nucleon). In addition, it provides measurements of the fluxes of the isotopes of carbon, nitrogen, and oxygen from ~5 to ~15 MeV/nucleon. The measurements from this experiment support studies of the origin, propagation, and solar modulation of galactic cosmic rays; the acceleration and propagation of solar flare and interplanetary particles; and the origin and transport of energetic magnetospheric particles observed in the plasma sheet, adjacent to the magnetopause, and upstream of the bow shock.

The extensive EIS data set has been utilized in comprehensive studies of solar, interplanetary, and magnetospheric processes. Correlative studies have involved data from other IMP investigations and from other spacecraft, as well as direct comparisons of EIS data from IMP-7 and IMP-8. We have recently been using data from our IMP-8 experiment to investigate the long term temporal history of anomalous oxygen at 1 AU over the years from 1972 to 1988, and we have been continuing our use of IMP data as a 1-AU baseline for collaborative gradient studies with the Pioneer and Voyager spacecraft in the outer heliosphere.

During the past year we extended our study of the temporal behavior of anomalous cosmic ray oxygen, at 1 AU to late 1992 (see Figure 2.3-1) where it overlaps with data from our newly launched MAST instrument on SAMPEX. Our IMP-8 instrument was the first to report the return of ACR oxygen to 1 AU in 1992, where the present flux level is ~5 to 10 times that at similar neutron monitor levels in 1971 and 1985.

On day 216 of 1992 the EIS suffered a partial failure that removes its ability to measure electrons and nuclei with $Z \geq 3$. Measurements of low energy H and He fluxes continue.

During the past year talks and papers based in IMP data were presented at the APS, the AGU, and the 23rd ICRC, and a paper was submitted to Geophysical Research Letters.

2.6.2. An Interstellar Cosmic Ray and Planetary Magnetospheres Experiment (CRS) for the Voyager Missions Launched in 1977

This experiment is conducted by this group in collaboration with F. B. McDonald (University of Maryland), J. H. Trainor (Goddard Space flight Center), W. R. Webber (NMSU), and J. R. Jokipii (University of Arizona), and has been designated the Cosmic Ray Subsystem (CRS) for the Voyager Missions. The experiment is designed to measure the energy spectra, elemental and (for lighter elements) isotopic composition, and streaming patterns of cosmic-ray nuclei from H to Fe over an energy range of 0.5 to 500 MeV/nucleon and the energy spectra of electrons with 3 - 100 MeV. These measurements will be of particular importance to studies of stellar nucleosynthesis, and of the origin, acceleration, and interstellar propagation of cosmic rays. Measurements of the energy spectra and composition of energetic particles trapped in the magnetospheres of the outer planets are used to study their origin and their relationship to other physical phenomena and parameters of those planets. Measurements of the intensity and directional characteristics of solar and galactic energetic particles as a function of the heliocentric distance will be used for *in situ* studies of the interplanetary medium and its boundary with the interstellar medium. Measurements of solar energetic particles are crucial to understanding solar composition and solar acceleration processes.

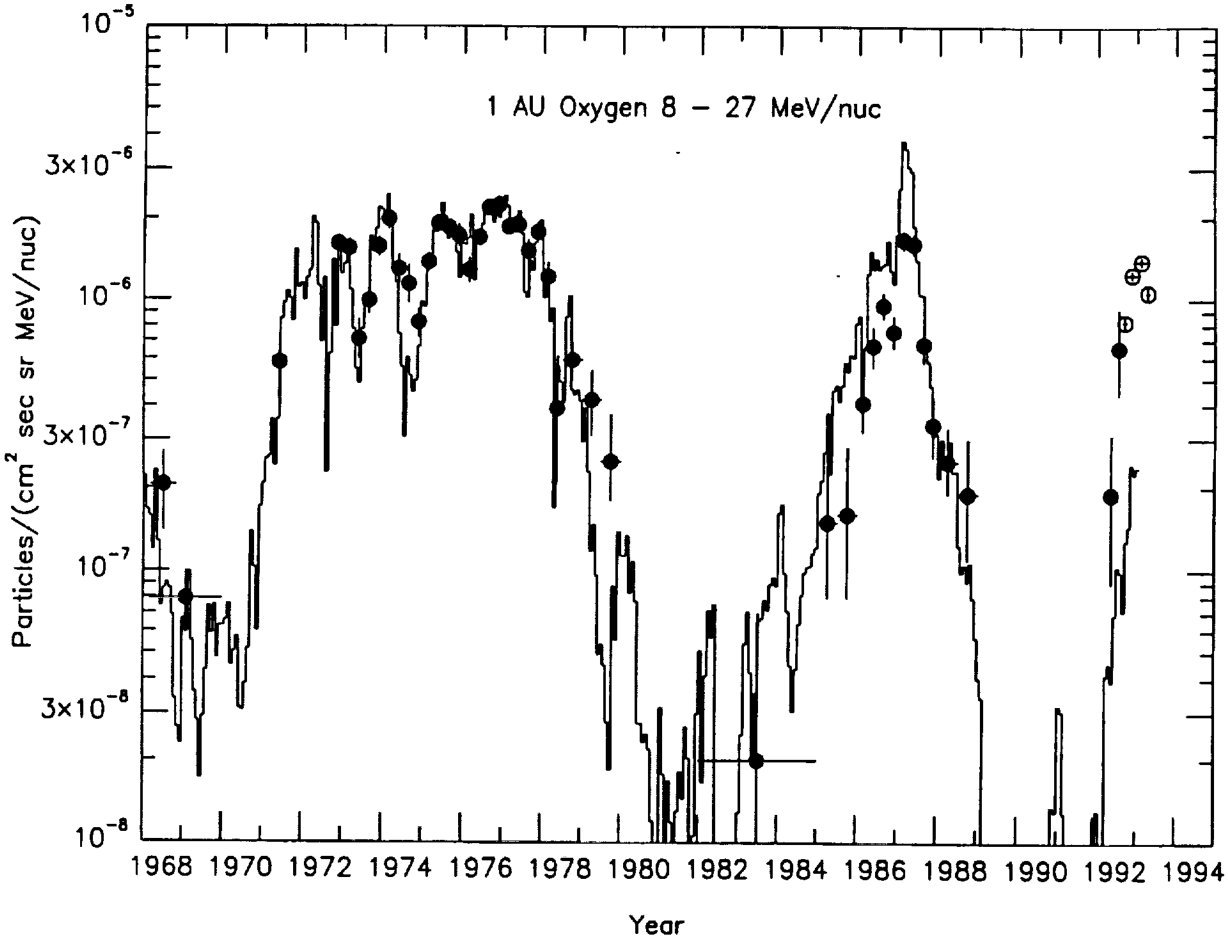


Figure 2.3-1: Solar Cycle Variations of Anomalous Oxygen

The CRS flight units on both Voyager spacecraft have been operating successfully since the launches on August 20, 1977 and September 5, 1977. The CRS team participated in the Voyager 1 and 2 Jupiter encounter operations in March and July 1979, the Voyager 1 and 2 Saturn encounters in November 1980 and August 1981, the Voyager 2 Uranus encounter in January 1986, and the Voyager 2 Neptune encounter in August 1989. The Voyager data represent an immense and diverse data set, and a number of scientific problems are under analysis. These investigation topics range from the study of galactic cosmic-ray particles to particle acceleration phenomena in the interplanetary medium, to plasma/field/energetic particle interactions, to acceleration processes on the sun, to studies of elemental abundances of solar, planetary, interplanetary, and galactic energetic particles, and to studies of particle/field/satellite interactions in the magnetospheres of Jupiter, Saturn, Uranus, and Neptune.

Using observations of the intensity of anomalous cosmic ray oxygen and helium and the current sheet tilt during the last solar minimum we have recently completed an estimate of the distance to the solar wind termination shock. We find that the termination shock was at 67±5 AU during the period 1986.5 - 1988.5. In 1997, both Pioneer 10 and Voyager 1 will pass 67 AU. These spacecraft might encounter the termination shock by that time.

2.6.3. A Heavy Ion Counter (HIC) Launched on Galileo in 1989

The Galileo Heavy Ion Counter (HIC) was constructed by this group in collaboration with N. Gehrels at Goddard Space Flight Center. It will monitor penetrating (~10 to ~200 MeV/nucleon) sulfur, oxygen, and other heavy elements in the Jovian magnetosphere with the sensitivity needed to warn of potential "single-event upsets" (SEUs) in the spacecraft electronics. These upsets are changes in states of electronic components induced by ionizing radiation of a single energetic particle. Caltech is responsible for managing operations and data analysis for this instrument. Although the primary mission is engineering support, the data are of significant scientific value and will allow us to continue our investigation of the spectra of trapped ions in the Jovian magnetosphere and their relation to the Jovian aurora. In addition, in the outer Jovian magnetosphere, we will use the instrument to measure the elemental composition of solar flare events and of the anomalous cosmic ray component. The measurements at 5 A.U. will be especially useful in the study of the radial dependence of the gradient of the ACR oxygen.

During the December 1992 Earth Encounter HIC data were telemetered for approximately 30 days, including the large solar flare events in early November. Thus we continue to be lucky in getting solar flare data during our small amount of coverage. The measurements of the 1989 October flares will be used in collaborative work with COSMOS and LDEF observations of those flares in the magnetosphere. We are also working on making the Galileo and Voyager flare composition measurements of heavy ions easily accessible to the SEU community.

Current activities are dominated by reprogramming the spacecraft to allow science to be done at vastly decreased telemetry rates and the resulting reprogramming of ground software.

2.6.4. A Solar and Magnetospheric Particle Explorer (SAMPEX)

In July of 1992 the Solar, Anomalous, and Magnetospheric Explorer (SAMPEX), on which we are co-investigators, was launched into polar orbit as part of the new Small Explorer (SMEX) program. SAMPEX is a collaboration between scientists at the University of Maryland (with G. M. Mason as P. I.), The Aerospace Corporation, Caltech, Goddard, and the Max-Planck Institut, and includes four instruments. Caltech, along with GSFC, furnished a Mass Spectrometer Telescope (MAST), and a Proton Electron Telescope (PET). These instruments are making new measurements of the isotopic composition of solar flare and anomalous cosmic rays with greatly improved collecting power, and measuring galactic cosmic ray isotopes and low-energy electrons. Among the unique measurements made possible by SAMPEX's polar orbit are a direct determination of the charge state of the anomalous cosmic ray component, and measurements of precipitating MeV electrons that may affect the atmospheric ozone balance.

SAMPEX data has already been used to make several significant studies, the most noteworthy of which is the confirmation that there is a belt of trapped anomalous cosmic rays circling the earth at $L \simeq 2$. (See Figure 2.3-2). Data from MAST shows that this new radiation belt contains the elements N, O, and Ne, but very little C. The first evidence for this belt was provided by the US/Russian Anomalous Cosmic Ray Team based on COSMOS measurements, thereby verifying the predictions of the Blake and Friesen model proposed in 1977. However data from MAST show that the belt is located at $L \simeq 2.2$ rather than at $L \simeq 3$ as predicted.

SAMPEX studies have already resulted in more than a dozen talks and papers.

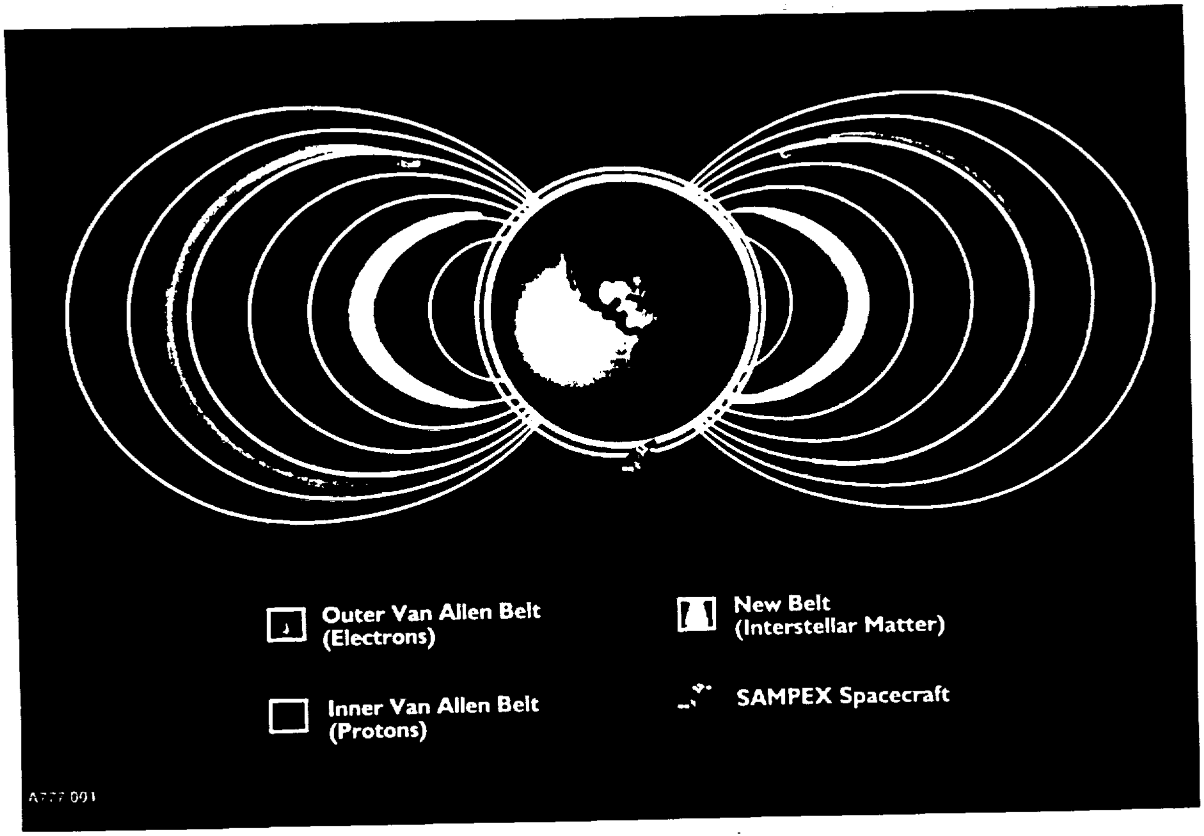


Figure 2.3-2 Radiation Belts

2.6.5. An Advanced Composition Explorer (ACE)

In April of 1991 we began the Phase-B study of an Advanced Composition Explorer (ACE). This investigation is conducted jointly by this group, (with E. C. Stone as P.I.) and by scientists from Applied Physics Lab/Johns Hopkins University, the University of Bern, the University of Chicago, Goddard Space Flight Center, Los Alamos National Laboratory, the University of Maryland, the University of New Hampshire and the Max-Planck Institut. The Phase B definition study is a 2 year effort. Launch is currently planned for 1997. ACE will make comprehensive measurements of the elemental and isotopic composition and the charge states of accelerated nuclei with increased sensitivity of several orders of magnitude, and with improved mass and charge resolution. It will observe particles of solar, interplanetary, and galactic origins, spanning the energy range from that of the solar wind (~ 1 keV/nucleon) to galactic cosmic ray energies (several hundred MeV/nucleon). Definitive studies will be made of the abundance of essentially all isotopes from H to Zn ($1 \leq Z \leq 30$), with exploratory isotope studies extending to Zr ($Z=40$).

The ACE study payload includes six high-resolution spectrometers, each designed to provide the ultimate charge and mass resolution in its particular energy range, and each having a collecting power 1 to 3 orders of magnitude greater than previous or planned experiments. Included in the study would be two spectrometers, a Solar Isotope Spectrometer (SIS), and a Cosmic Ray Isotope Spectrometer (CRIS), for which Caltech will play a leading role.

There are three main areas in which significant technical advances are being made for CRIS and SIS during Phase B.

VLSI Circuitry: Both SIS and CRIS employ multiple telescopes with a large number of detection elements. In order to pulse height analyze the large number of signals involved for limited weight and power we are developing VLSI versions of the required ADC chains during Phase B with the assistance of experienced subcontractors. The SIS and CRIS stack detectors will use the Harris "Fasttrack" system to provide a 12-bit ADC chain that requires only ~40 mW/channel. A second approach will use UTMC technology to read out each of the 512 strips of the SIS position-sensitive detectors. This circuitry has a number of possible applications for low-power instrumentation that could be used in future spacecraft and long-duration balloon experiments.

Large Area Solid State Detectors: During Phase B we are developing new position sensitive detectors for SIS with 32 cm^2 area. The CRIS stack detectors will be new 4-inch diameter Li - drift detectors with annular guard rings.

SOFT Hodoscope for CRIS: A Scintillating-Optical Fiber Trajectory (SOFT) hodoscope was selected for CRIS after a Phase-B study that ended in July 1992. This hodoscope, under development by Washington University, will provide increased geometry factor with very good position resolution. The approach of combining a SOFT hodoscope with large area solid state detectors was first proposed and texted under this grant several years ago. It has possible applications in other spaceflight experiments.

2.6.6. Astromag and Solar Probe

During the past year we participated in an on-going study of a Free-flying version of Astromag that would minimize costs, commensurate with the new emphasis in NASA on "Faster, Better, and Cheaper." It was found that the science goals for the Wizard and LISA Experiments could be accomplished by a scaled down Astromag launched into a polar orbit by a Delta launch vehicle. In this version of Astromag there are only minor reductions in the magnet size. Although significant reductions are necessary in the size of the experiments, this is to some extent compensated for by the greater yield that is achieved in a polar orbit.

2.6.7. Interstellar Probe

Interstellar Probe is a future mission concept that was given high scientific priority in the 1991 Space Physics Strategy Implementation study. A 1990 study chaired by T. Holzer, R. Mewaldt, and M. Neugebauer identified the scientific goals and a strawman payload for this mission, which is intended to make a comprehensive study of the solar wind termination shock, the heliopause, and the interstellar medium beyond.

In 1993 JPL initiated a small study to see if a scaled down mission could benefit from technology under development for the Fast Pluto Flyby mission, and for Solar Probe. R. Mewaldt is participating in this study and has been given the task of studying to what extent the scientific goals of Interstellar Probe can be accomplished with a payload of instruments requiring totals of ≤20 kg and 20 W. The results of this study are expected during the fall of 1993.

2.7. Other Activities

2.7.1. Space Radiation Effects on Biological and Electronic Systems

At the 1992 meeting of COSPAR two invited talks were given on the interplanetary environment of solar energetic particles, and galactic cosmic rays in an effort to more accurately assess their potential hazards for manned spaceflight and for spaceflight electronics. During late 1992 this material was written up for publication in the conference proceedings.

In July of 1993 a third paper on this topic was presented at the IEEE Conference on Radiation Effects. This later paper addresses the possible implications of trapped anomalous cosmic rays.

2.7.2. Interaction Cross Sections

SRL personnel participated in the UHIC collaboration measurement of interaction cross sections for fragmentation of gold at 10.6 GeV/nucleon at Brookhaven in April/May 1992. We are also participating in the data analysis for that data and the earlier LBL measurements. The Brookhaven trip was immensely successful, with data returned with quantity and quality much in excess of our expectations. These measurements are the first made with high-energy gold and are being reported to the nuclear physics community as well as space physics.

Two papers were presented at the International Cosmic Ray Conference in Calgary. One of the conclusions was that the energy dependence of Au-H cross sections are very much larger than generally assumed.

2.7.3. Small Instruments Workshop

In March of 1993 a Workshop sponsored by NASA HQ and JPL was held here in Pasadena to discuss concepts for future spacecraft instrumentation that would use new electronic and detector developments to achieve state of the art measurements for reduced weight, power, and cost ("faster, better, and cheaper"). Such instrumentation has possible application on missions such as Solar Probe and Interstellar Probe, as well as others. SRL personnel contributed four papers to this workshop, and also contributed to a recent workshop on instrumentation for the Pluto Fast Flyby Mission:

2.7.4. Other Laboratory Activities

Doug Rowland, a Caltech undergraduate, is currently constructing two new multi-wire proportional counters under the guidance of A. Davis and W.R. Cook. This counter, designed for use at accelerator calibrations, will supplement the present counters that we have used successfully over the past 15 years. The new counter will have ~4 times the active area of the present design. It uses a capacitive division readout scheme developed in our laboratory.

2.7.5. Community Service -- Committee Work and Miscellaneous

During the past year R. A. Mewaldt served as chairman of the Cosmic Ray Program Working Group and as a member of the CHMOWG. He also served on the Program Committee for the 23rd International Cosmic Ray Conference, and on the US/Russian Anomalous Cosmic Ray Team.

During the past year A. C. Cummings served as a member of the Committee on Solar-Terrestrial Relationships of the National Research Council, as a member of CHMOWG, as a member of the Heliospheric Program Working Group, and as a member of the Planetary Plasma Interactions Node Science Panel. In addition, he recently served as a member of the Science Definition Team for Space Physics Objectives for the Pluto Fast Flyby Mission.

T. L. Garrard served as a member of the Space Physics Data System Steering Committee and participated in the SPDS Workshop. He will serve as Cosmic and Heliospheric Co-ordinator for the new SPDS management structure developed at the workshop.

3. PLANNED ACTIVITIES

3.1. Data Analysis from the Isotope Matter/Antimatter experiment (IMAX)

During the coming year we will finalize our velocity measuring and mass determination algorithms for IMAX and turn our attention to analysis of the flight data. We will begin by assessing the efficiency of the Cherenkov counters for identifying high energy electrons and mesons that provide a background for antiproton measurements. Our highest studies will be a determination of the antiproton flux from ~0.1 to 3 GeV, and the analysis of the $^3He/^4He$ ratio at high energies.

3.2. The ISOtope Magnet experiment (ISOMAX)

Early in the coming fiscal year ISOMAX will have its critical design review, and we will begin fabrication of the flight instrument. Here at Caltech we will be ordering and testing photomultipher tubes, completing the design of the Cherenkov counter housing, and beginning fabrication. Aerogel radiators will be ordered and undergo sintering at DSRI to adjust their index to the design value of $n \approx 1.1$. We expect to have a working counter by the end of FY94.

We also expect to order the parts for the on-board recording system in the next few months, and to complete the fabrication and testing of this system.

Although there are still some open issues relating to the design of the gondola, we hope to address these during the next few months so that construction can begin on schedule. SRL will also be carrying out a structural and thermal analysis of the payload design during the next year.

A team meeting is scheduled for October 1994 to plan the ISOMAX schedule in more detail.

3.3. Experiments on NASA Spacecraft

3.3.1. IMP-8

During the coming year the major emphasis will be on further study of the ACR component over the years since 1972 using the IMP-7/8 data base. IMP data will also support Voyager/Pioneer measurements of cosmic ray spatial gradients in the heliosphere.

3.3.2. Voyager

Voyager activities during the coming year will focus on obtaining an improved estimate of the distance to the termination shock.

3.3.3. SAMPEX

Data from the MASS Spectrometer Telescopes (MAST) on SAMPEX will be used to conduct further studies of trapped anomalous cosmic rays, and the isotopic composition of heavy nuclei from solar flares and galactic cosmic rays. Data from the Proton Electron Telescope (PET) will be used to study the temporal variations and energy spectra of precipitating magnetospheric electrons.

2 pages

4. BIBLIOGRAPHY 1992 - 1993

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